The Progression of Refractive Error in School-age Children: Shunyi District, China

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• PURPOSE: To assess the progression of refractive error and the incidence of myopia in school-age children in the Shunyi District of Beijing, China.
• DESIGN: A longitudinal cohort study.
• METHODS: A population-based sample of 4,662 children initially examined in 1998 at ages 5 to 13 years was reexamined between September and November, 2000. Refractive error was measured under cycloplegia with autorefraction. Age, sex, and baseline refractive error were evaluated as risk factors for progression.
• RESULTS: In 28.5 months, the average change in refractive error was −0.42 diopters (standard deviation, 0.68) in right eyes. Myopic shift of refractive error was associated with female sex, older age, and higher myopic or hyperopic refractive error at baseline. The average change in astigmatic error was essentially zero, with significant change in both directions more likely among those with higher baseline astigmatism. Findings were similar for left eyes. The cumulative incidence of myopia, defined as a spherical equivalent refractive error of −0.50 diopters or more in either eye, among initial emmetropes and hyperopes was 14.1% (95% confidence interval [CI], 11.8%–16.5%) for male and 23.5% (95% CI, 20.8%–26.1%) for female subjects. Myopia incidence increased sixfold to sevenfold between baseline age 5 and 12, before decreasing at age 13, for both male and female subjects.
• CONCLUSIONS: In the design of cost-effective programs for the periodic screening and treatment of uncorrected refractive error, children initially found to require refractive correction should be targeted for relatively frequent rescreening, as should girls and older children. Further study is required to better understand environmental and genetic risk factors for myopia development and progression. (Am J Ophthalmol 2002;134: 735–743. © 2002 by Elsevier Science Inc. All rights reserved.)

Accepted for publication June 27, 2002.
InternetAdvance publication at ajo.com Oct 15, 2002.
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This study was performed by the Department of Ophthalmology, Peking Union Medical College Hospital, Beijing, China, and was supported by the World Health Organization, Geneva, Switzerland, under National Institutes of Health Contract N01-EY-2103.
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MYOPIC REFRACTIVE ERROR IS THE MOST COMMON eye condition in the world, with a substantial social, educational, and economic impact.[1] It is well known that the prevalence of refractive error varies widely, depending on geography, ethnicity, sex, and age.[2] That has been recently demonstrated in a series of five population-based studies carried out in school-age children in China, Nepal, Chile, and India.[3–7] The Refractive Error Study in Children (RESC) protocol[8] was used in all five surveys—two in India—enabling straightforward comparison of findings. The China survey was carried out in Shunyi District—an upper-middle class, rural community located northeast of metropolitan Beijing. The prevalence of refractive error in the Shunyi survey was higher than that found in the other four surveys: among those 15 years of age, myopia (at least −0.50 spherical equivalent diopter in either eye) was present in 55% of female and in 37% of male subjects. Refractive error has long been recognized as an important public health problem in China.[9]

The purpose of this follow-up study was to assess the progression of refractive error, including the incidence of myopia, in the Shunyi District population.

DESIGN

IN THIS LONGITUDINAL COHORT STUDY, CHILDREN ORIGINALLY examined in a population-based survey of refractive error in Shunyi District in 1998 were recontacted 2 years, 4 months later for reexamination, between September and November 2000. The original study sample of children 5 to 15 years of age was selected randomly using cluster sampling of villages throughout Shunyi District.[3]

0002-9394/02/$22.00
PII S0002-9394(02)01689-6

METHODS

IN THE SUMMER OF 2000, AND WELL BEFORE THE INITIATION of fieldwork, cooperation and support for the RESC follow-up project was obtained from the District Bureau of Public Health and the District Bureau of Education. After community endorsement was obtained, two enumeration teams, each with five enumerators, visited each of the original RESC sample villages to obtain updated information on all children examined in 1998. Using official village registers, enumeration staff reconfirmed household addresses, including changes for children who had relocated outside of the district, and identified the name of the current school for children still attending district schools.

After gathering demographic information, the enumerators accompanied two examination teams to 153 schools to assist with the identification of study children and with examination logistics. All components of the follow-up examination were carried out at the child's school, as in the original survey. Informed consent for the follow-up examination was obtained from the child's parent through a written notice sent to each home in advance by the school head.

Distance visual acuity measurements, both uncorrected and presenting for those wearing spectacles, were performed by one of the two ophthalmic assistants on each of the two examination teams using a logarithm of the minimum angle of resolution (logMAR) tumbling "E" chart (Precision Vision, La Salle, Illinois, USA). This was followed by ocular motility evaluation, anterior segment examination, and autorefraction with a hand-held Nikon Retinomax K-Plus (Nikon, Tokyo, Japan), all performed by the team ophthalmologist.

Pupils were dilated with two drops of cyclopentolate 1% administered 5 minutes apart by an ophthalmic assistant. After 20 minutes, if a pupillary light reflex was still present, a third drop was administered. Cycloplegia was considered complete if the pupil dilated to 6 mm or greater and light reflex was absent. After cycloplegic dilation, the team ophthalmologist took a second autorefraction measurement. Children with uncorrected visual acuity of 20/32 or worse in either eye also underwent subjective refraction by the team optometrist. The examination process was finalized with indirect or direct ophthalmoscopic examination of the lens, vitreous, and fundus. In eyes with uncorrected visual acuity of 20/32 or worse, the examining ophthalmologist designated a principal cause of impairment using a seven-item list (refractive error, amblyopia, corneal opacity resulting from trachoma, other corneal opacity, cataract, retinal disorder, other causes).

Except for the addition of autorefraction measurements before cycloplegia and the deletion of cycloplegic retinoscopy, the follow-up examination followed the original RESC protocol.[8]

The estimation of change in refractive error in each eye over the follow-up interval was based on cycloplegic autorefraction measurements—calculated as the follow-up measurement minus the original baseline measurement. Only children with cycloplegic dilation in both eyes were included in this analysis. Changes in refractive error were analyzed with respect to sex, age, and the amount of refractive error at baseline. Multiple logistic regression was used to investigate the association of these covariates with myopic progression, using progression thresholds of −0.50 diopters and −1.00 diopters. Changes in astigmatism were similarly investigated.

The age-specific incidence of new cases of myopia among initial emmetropes and hyperopes—the at-risk population—was estimated for both males and females. The association of age, sex, and baseline refractive error with myopia incidence was investigated with multiple logistic regression. The prevalence of ametropia at follow-up was also estimated. As in the original RESC study, myopia was defined as spherical equivalent refractive error of at least −0.50 diopters, and hyperopia as +2.00 diopters or more. A child was classified as a myopic individual if either eye had myopia, as a hyperope if either eye had hyperopia (so long as myopia was not present in the fellow eye), and as an emmetrope if neither eye had myopia or hyperopia.

Confidence intervals (CI) for estimates were calculated with variance adjustment for clustering effects associated with the sampling design.[10,11] (The sampling of the Shunyi population utilized geographical clusters based on village boundaries.) The magnitude of cluster design effects is expressed by a ratio, deff (design effect), which compares the estimate of variance actually obtained for the particular variable under evaluation with that that would have been obtained through simple random sampling. Clustering effects are large when there is a high degree of homogeneity within clusters and heterogeneity between clusters for the variable being estimated.

Pair-wise interactions between model variables in logistic regressions were assessed simultaneously using a Wald F test,[10] and considered significant at the $P < .10$ level. Lack of independence between measurements in right and left eyes of the same child was dealt with by keeping right and left eyes separate in analyses of such data. Missing data were omitted from the analyses—and thus implicitly assumed to be similar in distribution to that of available data.

Human subject research approval for the original RESC protocol was obtained from the World Health Organization Secretariat Committee on Research Involving Human Subjects. Approval to conduct the follow-up study was obtained from the Department of Research of the Peking Union Medical College Hospital, Beijing, China.

RESULTS

IN THE ORIGINAL 1998 SURVEY, 6,134 CHILDREN BETWEEN 5 and 15 years of age were enumerated and 5,884 were

TABLE 1. Enumerated and Examined Study Population by Baseline Age

Baseline Age (years)	No. (%) Enumerated at Baseline	No. (%) Examined		Examination Follow-up Percentage
		Baseline	Follow-up	
5	114 (2.2)	103 (2.1)	92 (2.0)	89.3
6	208 (4.1)	199 (4.0)	189 (4.1)	95.0
7	375 (7.3)	358 (7.2)	344 (7.4)	96.1
8	619 (12.1)	595 (12.0)	571 (12.3)	96.0
9	866 (17.0)	855 (17.2)	832 (17.9)	97.3
10	843 (16.5)	824 (16.5)	793 (17.0)	96.2
11	822 (16.1)	814 (16.3)	778 (16.7)	95.6
12	710 (13.9)	704 (14.1)	672 (14.4)	95.0
13	552 (10.8)	527 (10.6)	391 (8.4)	74.2
All	5,109 (100.0)	4,979 (100.0)	4,662 (100.0)	93.6

examined. At the follow-up study in the fall of 2000, some of those originally examined were no longer residing in Shunyi District. Generally, these were older children who had completed schooling and had left the Shunyi area for work in nearby Beijing or other larger cities in China. Others had left the area for further education. Accordingly, it was not possible to obtain follow-up examinations for 65% of those who were 15 years of age at baseline—and 17 to18 years of age at the time of the follow-up. Follow-up examinations were not possible also for 47% of children 14 years old at baseline. Any attempt to examine these children at off-site locations was considered impractical. Baseline 14- and 15-year-olds were, therefore, excluded from the follow-up study. What remained was a study sample of 4,979 children between the baseline ages of 5 and 13 years. As shown in Table 1, these children were a subset of the 5,109 children of age 5 to 13 years enumerated at baseline. (The skewed age distribution of the enumerated population reflects the Chinese government's one-child policy, introduced in the mid-1980s.[3])

The percentage of baseline examinees with follow-up examinations was 95% or more for each year of age except for 5- and 13-year-olds (Table 1). Similarly, age- and sex-specific rates for the baseline 6- to 12-year age range were 93% or better (data not shown). The follow-up of baseline 13-year-olds—15 or 16 years of age at the time of the follow-up—was affected by migration out of the district for work or education, as was the case with baseline 14- and 15-year-olds.

In logistic regression modeling to investigate the influence of baseline refractive error on follow-up success, with age and sex as covariates, younger age and emmetropia at baseline were significant: Follow-up was successful in 94.4% of those with emmetropia in both eyes at baseline, vs 90.3% in baseline ametropes. Younger age was a significant predictor of follow-up success primarily because of the relatively low follow-up response among baseline 13-year-olds. Sex was not significant ($P = .692$). Similar results were obtained with a model using baseline visual acuity in place of refractive error: those with uncorrected visual acuity of ≥20/32 in the better eye were more likely to have a follow-up examination than those with vision impairment (94.1% vs 86.8%).

Follow-up examinations took place an average of 28.5 months (standard deviation [SD], 1.2) after the initial examination at baseline. Of those with follow-up examinations, 51.5% were male—ranging from a low of 43.3% for baseline 6-year-olds to a high of 57.6% for 5-year-olds.

Nineteen of the 4,662 children with follow-up examinations were excluded from refractive error analyses because of ocular pathology sufficient to be the principal cause of visual acuity impairment at baseline (11 cases) or at follow-up (15 cases). It was necessary to exclude an additional 22 examined children from refractive error analyses because of inadequate cycloplegic dilation at baseline or follow-up.

Change in spherical equivalent refraction during the follow-up interval ranged from −6.25 diopters to +2.00 diopters, with a mean of −0.42 diopters (SD, 0.68) for both right and left eyes. The 95% CI around this estimate of the mean was −0.37 diopters to −0.47 diopters. The extremes included, for example, 12 eyes of 6 children with myopic shift of −4.00 diopters or more. These eyes were all emmetropic at baseline, with progression to significant myopia over the 28.5-month interval. Among cases with hyperopic shift (those becoming more positive), 35 right eyes and 34 left eyes had change of more than +1.00 diopters.

The distribution of change in refractive error by age at baseline in right eyes of males and females is shown in Figure 1. The mean change was −0.32 diopters (SD, 0.65) in males (95% CI, −0.27 diopters–−0.36 diopters) and −0.53 diopters (SD, 0.70) in females (95% CI, −0.47 diopters–−0.59 diopters). Findings for left eyes were similar.

The distribution of change as a function of refractive status at baseline is shown in Figure 2. The mean change in baseline myopic eyes (refractive error of at least −0.50 diopters) was −0.84 diopters, vs −0.36 diopters in all other eyes. Again, left eyes were similar.

The apparent association of change in refractive error with increasing age, with female sex, and with higher refractive error (either myopic or hyperopic) at baseline was investigated with logistic regression. Because of the nonlinear relationship between baseline refractive error and refractive error change (Figure 2), eyes with a baseline spherical equivalent refractive error of ≤0.0 diopters were modeled separately from those with refractive error of >0.0 diopters. Refractive error status at baseline was modeled as a continuous variable. For right eyes with baseline refractive error of ≤0.0 diopters, myopic progression of at least −0.50 diopters was associated with female sex (odds ratio [OR], 1.87; 95% CI, 1.42–2.47), older age (OR, 1.14; 95% CI, 1.06–1.24), and higher myopic refrac-

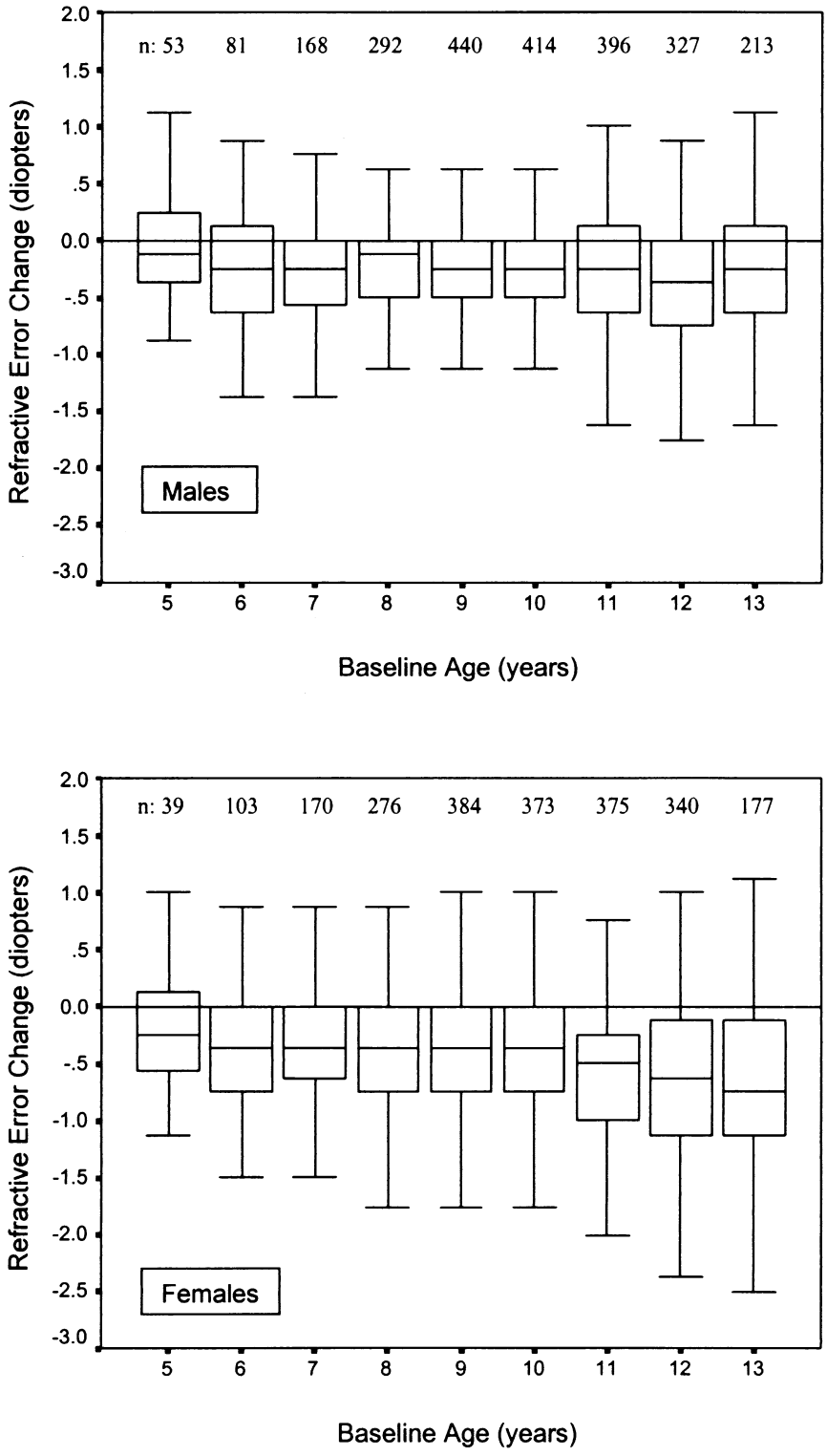
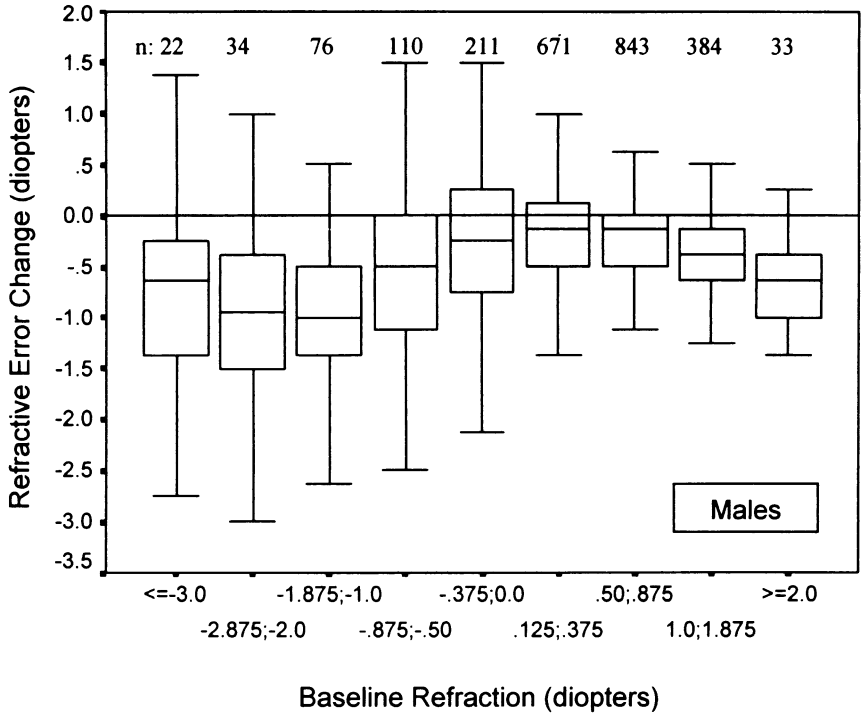


FIGURE 1. Box plot representations of the distribution of change in spherical equivalent refractive error in right eyes of male and female subjects as a function of age at baseline. The box extends from the 25th to the 75th percentile, the interquartile range, with the bar inside each box representing the median. The whiskers extend to the lower and upper extremes, defined as the 25th percentile minus 1.5 times the interquartile range and the 75th percentile plus 1.5 times the interquartile range. Sample sizes for each age group are shown.



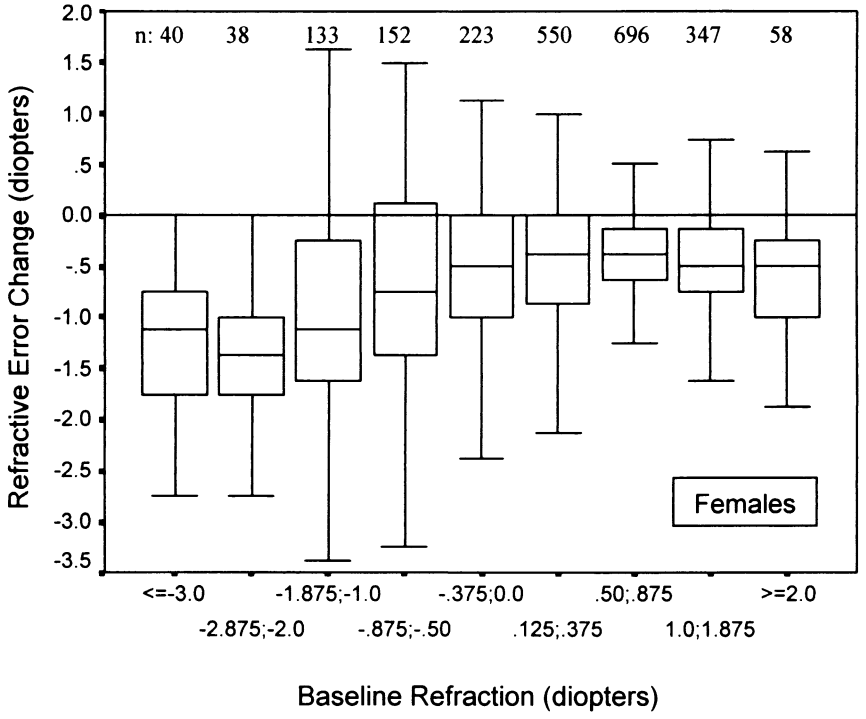


FIGURE 2. Box plot representations of the distribution of change in spherical equivalent refractive error in right eyes of male and female subjects as a function of refractive error at baseline. Sample sizes for each baseline refractive error group are shown. (See Figure 1 caption for an explanation of box plots.)

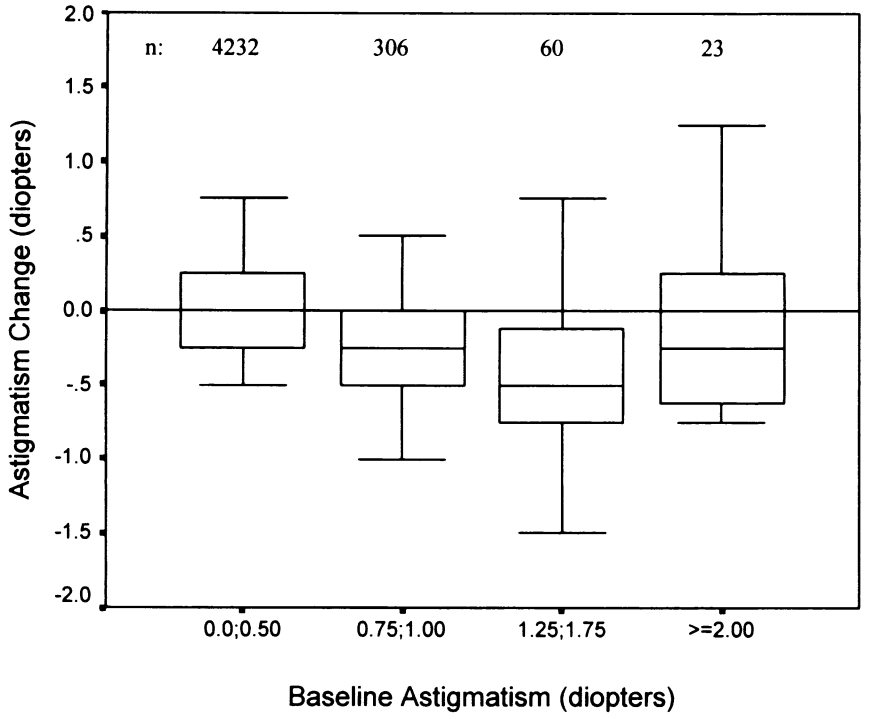


FIGURE 3. Box plot representations of the distribution of change in astigmatism in right eyes as a function of astigmatic error at baseline. The positive portion of the ordinate indicates increasing astigmatism and the negative portion decreasing astigmatism. Sample sizes for each baseline astigmatism group are shown. (See Figure 1 caption for an explanation of box plots.)

tive error at baseline (OR, 1.71; 95% CI, 1.38–2.11). These model covariates were also significant for left eyes. When only eyes that were myopic (≤ −0.50 diopters) at baseline were modeled—removing emmetropic eyes from the regression model—baseline refractive error remained significant (OR, 1.33; 95% CI, 1.03–1.72), but the association with female sex (OR, 1.31; 95% CI, 0.93–1.83) and older age (OR, 1.07; 95% CI, 0.95–1.22) was no longer statistically significant.

Upon increasing the myopic progression threshold to −1.00 diopters, sex and baseline refractive error remained statistically significant for right eyes with baseline refractive error ≤0.0 diopters, but age did not ($P = .16$). The same findings were present in the model with only myopic eyes.

In modeling right eyes with refractive error of >0.0 diopters at baseline, myopic shift of at least −0.50 diopters was associated with female sex (OR, 1.89; 95% CI, 1.58–2.25), older age (OR, 1.07; 95% CI, 1.01–1.13), and with higher hyperopic refractive error at baseline (OR, 1.40; 95% CI, 1.16–1.69). For left eyes, the association with older age was not statistically significance ($P = .13$); however, sex and baseline hyperopia remained significant. With a change of at least −1.00 diopters, the amount of baseline hyperopic refractive error in right eyes was of marginal significance ($P = .075$), but remained statistically significant for left eyes. Older age and female sex remained significant for both right and left eyes with the −1.00-diopters change threshold.

Within the entire study population, the magnitude of astigmatic error showed little change over the 28.5-month period: an estimated mean decrease of 0.004 cylindrical diopter (SD, 0.301) in right eyes, and an estimated mean increase of 0.001 diopter (SD, 0.297) in left eyes. Almost all cases had cylindrical measurements of less than 0.75 diopter at both baseline and follow-up. For the 8.4% of eyes with 0.75 diopter or more of astigmatic error at baseline, a general decrease in astigmatism was found. Figure 3 shows the change in astigmatic error within each of four categories of astigmatism at baseline.

It was found with multiple logistic regression modeling that among those cases with increasing astigmatic error, an increase of 0.50 diopter or more was associated with older age (OR, 1.12; 95% CI, 1.06–1.18). Cylindrical increases of at least 1.00 diopter were associated with greater astigmatic error at baseline (OR, 3.35; 95% CI, 1.80–6.06) and female sex (OR, 3.22; 95% CI, 1.07–9.68), but not age. The amount of reduction in astigmatic error, naturally, had a direct association with the amount of astigmatism initially present. In regression modeling, age and sex were not associated with diminution of astigmatic error.

Table 2 compares the ametropic status of children at baseline—based on refractive error in both eyes—with

TABLE 2. Number (%) of Children With Ametropia at Baseline and at Follow-up

	Follow-up			
	Hyperopes	Emmetropes	Myopes	All
Baseline				
Hyperopes	81 (58.3)	54 (38.8)	4 (2.9)	139 (3.0)
Emmetropes	14 (0.37)	3,028 (80.5)	718 (19.1)	3,760 (81.4)
Myopes	0 (0.0)	110 (15.2)	612 (84.8)	722 (15.6)
All	95 (2.1)	3,192 (69.1)	1,334 (28.9)	4,621 (100.0)

FIGURE 4. Age-specific cumulative 2 year, 4 month incidence of myopia among male and female emmetropes/hyperopes as a function of age at baseline.

that at follow-up. The incidence of new myopes among baseline emmetropes and hyperopes was 18.5% (722/3,899). Accompanying these new cases of myopia were 110 children who were considered myopic at baseline, but who were no longer so at follow-up. After accounting for this apparent "emmetropization" of baseline myopes, the prevalence of cases with myopia increased to 28.9%, up from 15.6% at baseline. And the prevalence of hyperopia decreased to 2.1% at follow-up, up from 3.0% at baseline.

The cumulative incidence of myopia over the 28.5-month period is shown in Figure 4 as a function of baseline age, for both males and females. Incidence was lowest among baseline 5-year-olds: 3.8% (95% CI, 0.47%–13.2%) for males and 5.3% (95% CI, 0.64%–7.7%) for females. Incidence peaked at 25.3% (95%CI, 19.3%–31.2%) at 12 years of baseline age for males, and at 39.6% (95% CI, 32.4%–46.8%) for females, also at 12 years of baseline age. Considering all ages, incidence was 14.1% (95% CI, 11.8%–16.5%) for males and 23.5%% (95% CI, 20.8%–26.1%) for females. The cumulative incidence of myopia for the study population as a whole (as noted above) was 18.5% (95% CI, 16.4%–20.7%). In logistic regression modeling of myopia incidence with age and sex as covariates, the odds ratio for age was 1.27 (95% CI, 1.20–1.35)—reflecting a 27% increase in the cumulative risk of myopia with each additional year of baseline age—and 1.95 (95%CI, 1.61–2.35) for sex, reflecting a nearly twofold risk for females compared with males.

DISCUSSION

THERE WAS SUBSTANTIAL CHANGE IN REFRACTIVE ERROR as measured by cycloplegic autorefraction: an estimated

mean change within the study population of −0.42 diopters (spherical equivalent) in both right and left eyes. This myopic shift in refractive error was associated with older age, female sex, and higher refractive error at baseline (either myopic or hyperopic error). The percentage of baseline emmetropes/hyperopes that progressed to myopia during the 2 year, 4 month period increased consistently from age 5 through 12 at baseline for both male and female cohorts, before decreasing in the 13-year age cohort. An eventual decrease in the age-specific incidence of myopia is to be expected: as those vulnerable to myopic development become myopic, only the more resistant cases are left, which results in an eventual drop-off in the incidence of myopia.

On an annualized basis, the estimated incidence of myopia ranged from 1.6% to 10.7% for males and from 2.2% to 16.7% for females. The annualized incidence across all ages and both sexes was 7.8%. Although the average amount of astigmatic error was found to be modest and did not change significantly during the follow-up interval, those presenting with substantial astigmatic error at baseline were more likely to experience change—in both positive and negative directions.

It was intended that the follow-up study would reexamine all of the initially examined children. However, because of an inability to achieve reasonable rates of reexamination in 14- and 15-year-old cohorts, these children were excluded from the follow-up study. Findings pertaining to these two age groups would have been subject to potentially significant bias. Because examination response rates for the 5- to 13-year age cohorts were generally high, the study findings should be representative of the rural Shunyi area—and possibly other, similar areas throughout China.

Although examination response was relatively low among baseline 13-year-olds, it should be recognized that the deficit of new myopia cases in this age cohort is not because they were among those not attending the follow-up examination: among the unexamined who were at risk for myopia at baseline (one fourth were not at risk because they were already myopic), more than half would have had to develop myopia for the incidence of myopia in 13-year-olds to merely equal that of 12-year-olds.

Because emmetropes and those without vision impairment at baseline were somewhat more likely to come for follow-up examination, it is possible that refractive error change for the study population as a whole was slightly underestimated. (Emmetropic eyes were found to have comparatively small changes in refractive error.) There was no attempt to ascertain why children, or their parents, refused examination. It is possible that those with ametropia or vision impairment, or both, detected at baseline were more inclined to forgo the follow-up screening, because they already knew that they had a vision problem and were given corrective spectacles after the baseline examination.

As illustrated in Figures 1 and 2, some of the change in refractive error represented hyperopic shift—not what is generally expected. Accordingly, some of the children categorized as myopes at baseline were no longer so at follow-up, and a few initial emmetropes were hyperopes at follow-up. As demonstrated earlier, the 95% limits of agreement for repeat cycloplegic autorefraction with the Nikon Retinomax K-Plus are approximately ± 0.50 diopters.[3] Although not particularly significant from a clinical standpoint, this test/retest variation—reflecting measurement error at both baseline and follow-up—was no doubt responsible for some of the recategorization necessitated by a small change in refractive error. (Three fourths of children recategorized because of hyperopic shift had a change of +0.50 diopters or less in one or both eyes; data not shown.) Similarly, measurement error was responsible for some of the recategorization brought on by small myopic changes.

For eyes with a hyperopic shift clearly outside the limits of measurement error, residual accommodative response at baseline because of unrecognized, incomplete cycloplegia may have been a contributor—incomplete cycloplegia that went unrecognized on the basis of pupillary dilation and light reflex testing. However, in the absence of obvious inconsistencies between baseline autorefraction, retinoscopy, and visual acuity measurements, it was not possible to find cases where inadequate cycloplegia clearly was a factor. Similarly, the possibility of unrecognized, incomplete cycloplegia at follow-up was investigated by comparing uncorrected visual acuity obtained at follow-up with that at baseline for eyes with particularly high myopia progression (of −4.00 diopters or more). Consistency between a change in refractive error and change in visual acuity for these cases suggested that these large myopic changes in refractive error were real and not an artifact of inadequate cycloplegia or some other problem with refraction.

Clustering of refractive error associated with environmental and genetic influences within families[12] or because of similar influences at the village level is embedded in study findings. Because it is rare for a family to have two children of the same age, clustering of refractive error at the family level had no influence on age-specific estimates. Clustering at the village level, however, remained influential, such as might be brought about by village-level differentials in socioeconomic status or the emphasis given to education. Deff values increased as the variable of interest went from being age-specific to sex-specific to completely general (data not shown). For example, a large deff (5.129) was associated with the 95% CI around the estimated mean change in refractive error for children of all ages and both sexes, which indicated that substantial clustering effects were present, consisting of clustering at both familial and community levels.

To the authors' knowledge, the longitudinal data reported in this article are the first from a population-based

cohort of children residing in the People's Republic of China. With respect to the findings reported here, four recent longitudinal studies of Chinese children living in Hong Kong and Singapore are of particular interest. Our estimated mean rate of myopic progression, −0.17 diopters per year, is considerably lower than that found in these earlier studies: Progression of −0.32 diopters per year was found in a 5-year study of 83 children in Hong Kong initially of age 7 years[13]; progression of −0.32 diopters per year was also found in a 2-year follow-up of 142 Hong Kong children aged 6 to 17 years[14]; and progression of −0.87 diopters per year was found in a 10-month study of 168 children 7 to 12 years of age in Singapore.[15] For eyes that were already myopic at baseline, we found myopia progression of −0.35 diopters per year—in contrast to a higher myopia progression of −0.60 diopters per year found in 153 myopic children 6 to 12 years of age in a contact lens trial in Singapore,[16] or the progression of −0.46 diopters per year found among baseline myopes in the previously mentioned 2-year Hong Kong study.[14] We found myopic shift to be associated with older age, which is counter to the finding of higher myopic progression rates among younger children in these other studies.[14–16] Our finding that myopia progression was also associated with higher levels of baseline myopia replicated findings from these other studies.[14,16]

Because these earlier longitudinal studies were not from a population-based sample, but instead were from children recruited from a community health center, from schools, or as volunteers for a clinical trial, they are subject to potentially significant biases. Comparisons are also limited because of different examination methods, nonuniform definitions for myopia/hyperopia, and differences in the age and sex mix of the populations studied.[1] Differences between our findings and those reported by others, and among studies in general, must therefore be interpreted with extreme caution, even when they pertain to populations from related geographic areas and with similar genetic makeup.

Our longitudinal study of refractive error in school age children has several attractive features, not the least of which is the random selection of a large population-based sample. The original sample size was calculated on the basis of providing reasonably accurate age- and sex-specific estimates of the prevalence of refractive error.[8] The study cohort included those ages that were expected to experience the highest incidence and progression of myopia. Accordingly, this new information on the dynamics of refractive error in school-age children is an important complement to previous population-based prevalence data.

In the development of cost-effective programs for the periodic screening and treatment of uncorrected refractive error among school-age children, our findings indicate that children initially found to require refractive correction should be targeted for rescreening on a more frequent schedule, compared with what might be considered appropriate for emmetropes. Female children and older children, regardless of refractive status, might also be considered for more frequent rescreening. Data regarding potential environmental influences on refractive error progression, such as near work and socioeconomic status, were not collected in our longitudinal survey, nor were genetic-related data.[15–17] New large-scale longitudinal studies of a similar nature, but which include the collection of environmental/genetic data, are necessary if risk factors for myopia development and progression are to be more conclusively understood.

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